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California Education and the Environment Initiative

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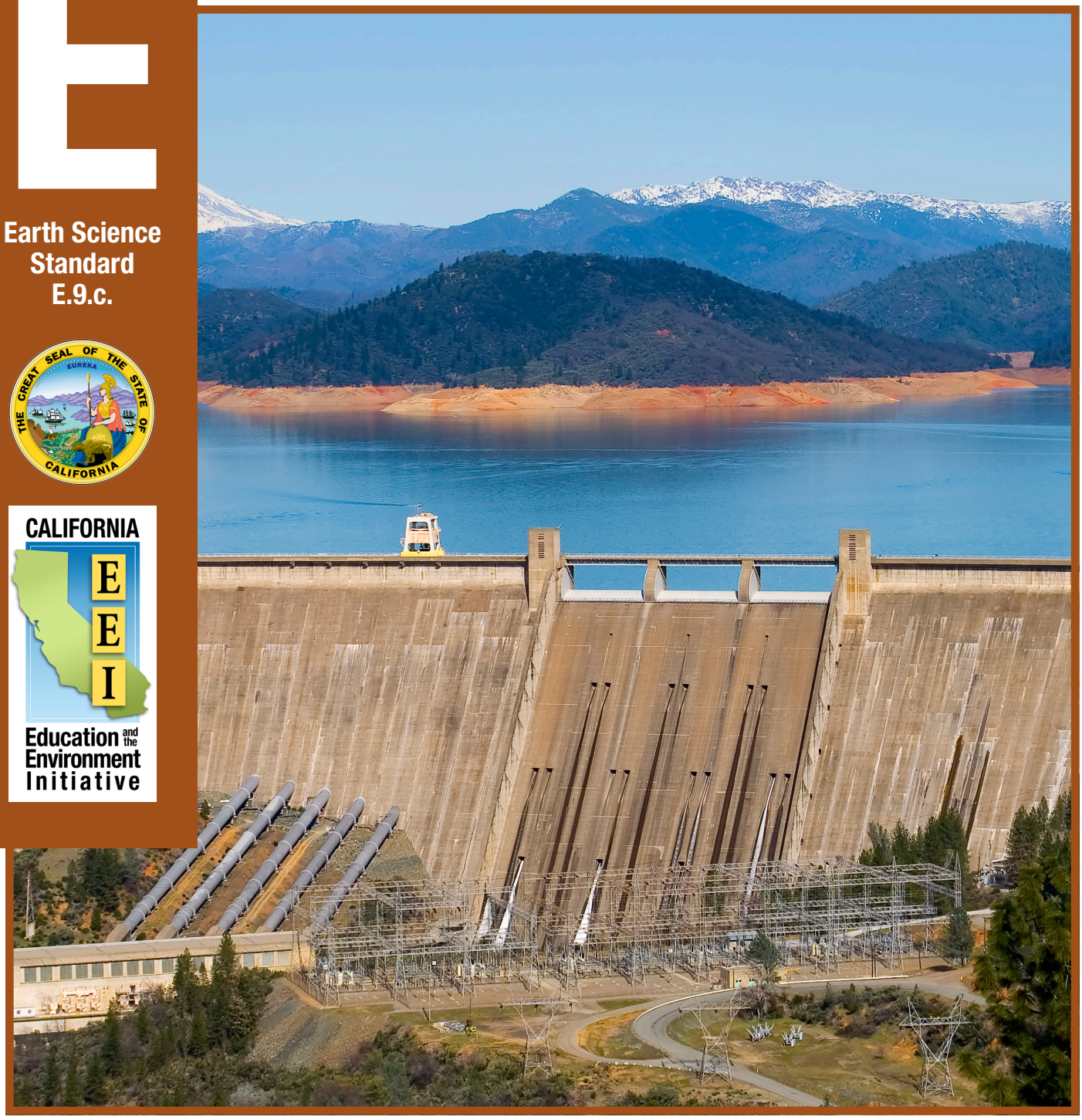

Liquid Gold: California's Water

California Education and the Environment Initiative

Approved by the California State Board of Education, 2010

The Education and the Environment Curriculum is a cooperative endeavor of the following entities:

California Environmental Protection Agency

California Natural Resources Agency

Office of the Secretary of Education

California State Board of Education

California Department of Education

California Integrated Waste Management Board

Key Leadership for the Education and Environment Initiative:

Linda Adams, Secretary, California Environmental Protection Agency

Patty Zwarts, Deputy Secretary for Policy and Legislation, California Environmental Protection Agency

Andrea Lewis, Assistant Secretary for Education and Quality Programs, California Environmental Protection Agency

Mark Leary, Executive Director, California Integrated Waste Management Board

Mindy Fox, Director, Office of Education and the Environment, California Integrated Waste Management Board

Key Partners:

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Office of Education and the Environment

1001 I Street • Sacramento, California 95812 • (916) 341-6769

http://www.calepa.ca.gov/Education/EEI/

Contents

Taking Charge of the Bay-Delta

Water is California's most precious resource, helping to fuel a $400 billion economy, the eighth largest in the world. Unfortunately, water is not always available where and when we need it. About two-thirds of California's water falls as rain and snow in the northern and eastern parts of the state, but most of the people, farms, and industries lie to the south and west.

To address this mismatch, local, state, and federal governments built dams to store water and canals and aqueducts to transport it to the San Joaquin Valley, the San Francisco Bay Area, and Southern California. Much of this water flows through what is the "hub" of California's water system—the Sacramento-San Joaquin Delta.

San Francisco Bay (Bay) and the Sacramento-San Joaquin Delta (Delta)

Two major rivers, the Sacramento and the San Joaquin, draining snowmelt and runoff from most of the Sierra Nevada, join in the Delta and flow to the Pacific Ocean through San Francisco Bay. The Bay and Delta represent the largest estuary on the Pacific Coast of the Americas. An estuary is an environment where fresh water mixes with sea water. The Delta is situated at the eastern edge of the estuary where the rivers join. The Delta includes 57 islands, 1,100 miles

Sacramento River

(1,770 kilometers) of levees, and hundreds of thousands of acres of marshes, mudflats, and farmland. It provides habitat for fish, invertebrates, waterfowl, and aquatic mammals. The Delta provides recreational fishing and boating opportunities and supports 80% of the state's commercial salmon fishery. Drinking water for 25 million Californians and water to irrigate nearly 5 million acres of farmland in the Central Valley flows through the Delta. The Delta also contains a number of communities, representing a unique part of California's culture and heritage, and supports numerous highways, pipelines, rail routes, and electric transmission lines.

Bay-Delta watershed

History of the Delta

Prior to the California Gold Rush in 1849, the Delta was mostly an untouched natural environment, consisting of river channels and a million acres of wetland marshes. During the Gold Rush, numerous riverboats traversed the Delta, carrying arriving miners from San Francisco to Sacramento and the gold fields beyond. The legacy of the Gold Rush is still felt today in the Bay-Delta system. For example, toxic mercury, used in gold extraction, still causes ecological harm. The development of the Delta as it is today began in 1850, when ownership of this waterlogged region was transferred from the federal government to the state.

The state sold the land to private interests, and over the next several decades, channels were dredged and the sediments used to build levees to hold back the water and allow farming on Delta "islands" that were at or below sea level. By the mid-1900s, 700,000 acres of farmland, more than 1,000 miles (1,610 kilometers) of levees, and hundreds of miles of waterways had transformed the Delta. Conversion of marsh and riparian habitat affected native plants and animals; nesting populations of shorebirds were eradicated, and habitat that served as nurseries for some fish, shellfish, and crustaceans was drastically reduced.

In the 1940s and early 1950s, the federal government

constructed the Central Valley Project to capture and store runoff from the Sacramento River and its tributaries and convey it across the Delta to irrigate the San Joaquin Valley. In the 1960s, the state followed suit with construction of the State Water Project to serve farms and the growing population of Southern California and the San Francisco Bay Area. On the average, the two projects pump about 1.6 trillion gallons (7 trillion liters) of water per year from the south end of the Delta, making the Delta truly the "hub" of California's water system.

Reinforcing levees

The Delta in Crisis

The Delta faces many challenges. The levees that formed the delta islands were not designed nor built to support the multibillion dollar economy that depends on the Delta. Subsidence, or sinking of the land, is caused by oxidation of peat soils when exposed to air, and contributes to the instability of the levees. This area has historically been subject to flooding, which occurred as recently as the spring of 2006. The levees can collapse during floods, and a moderate earthquake on one of the nearby faults could cause numerous levee failures. With such an event, salt water from the Bay would rush into the islands, rendering the water undrinkable, and ceasing water exports for months or years. The threat of sea level rise caused by global climate change further increases the risk of levee failure.

Since the completion of the last major state or federal water project, California has experienced enormous population and economic growth, putting greater stress on the state's water supplies and leading to conflicts over water exports from the Delta. For several decades, the increasing need to export water has influenced the functioning of the Delta ecosystem, often to its detriment.

Actions to Protect and Restore the Delta

A six-year drought, beginning in 1987, brought water conflicts to a head. State and federal agencies began working to improve water quality and fish populations, and ensure continued water exports from the Delta. However, their actions were not coordinated, and the agencies involved were often at odds. It became clear that the key stakeholders in this issue (farmers, municipal water users, state and federal governmental agencies, and environmental advocates) needed to seek common ground if anything was to be achieved.

What resulted was the San Francisco Bay-Delta Accord, enacted in 1994. The accord called for the creation of a joint federal and state program to manage the long-term restoration of the Bay-Delta and for the costs of the program to be split evenly between the state and federal governments. The accord provided the legal framework for the creation of the CALFED Bay-Delta Program (CALFED)—the coalition of

state and federal agencies that manage the Bay-Delta's water and environment.

In 2000, CALFED issued an environmental impact report (EIR) that identified hundreds of actions to restore and protect the Delta. In response to this EIR, the California Legislature enacted the California Bay-Delta Act of 2003, creating the CALFED Bay-Delta Authority as the new government entity to coordinate the CALFED Bay-Delta Program. The act charged the Authority to oversee the 24 state and federal agencies working cooperatively to solve the problems of the Delta.

CALFED agencies faced enormous challenges to implement this large and technically complex effort. The CALFED Program was strongly criticized; many people believed that CALFED was ineffective and lacked strong leadership. In 2005, after five years and $3 billion in spending, the governor and state legislature questioned the progress and the ability of the CALFED Program to lead the restoration of the Delta. Despite so much effort, a comprehensive solution to the Delta's problems was still elusive.

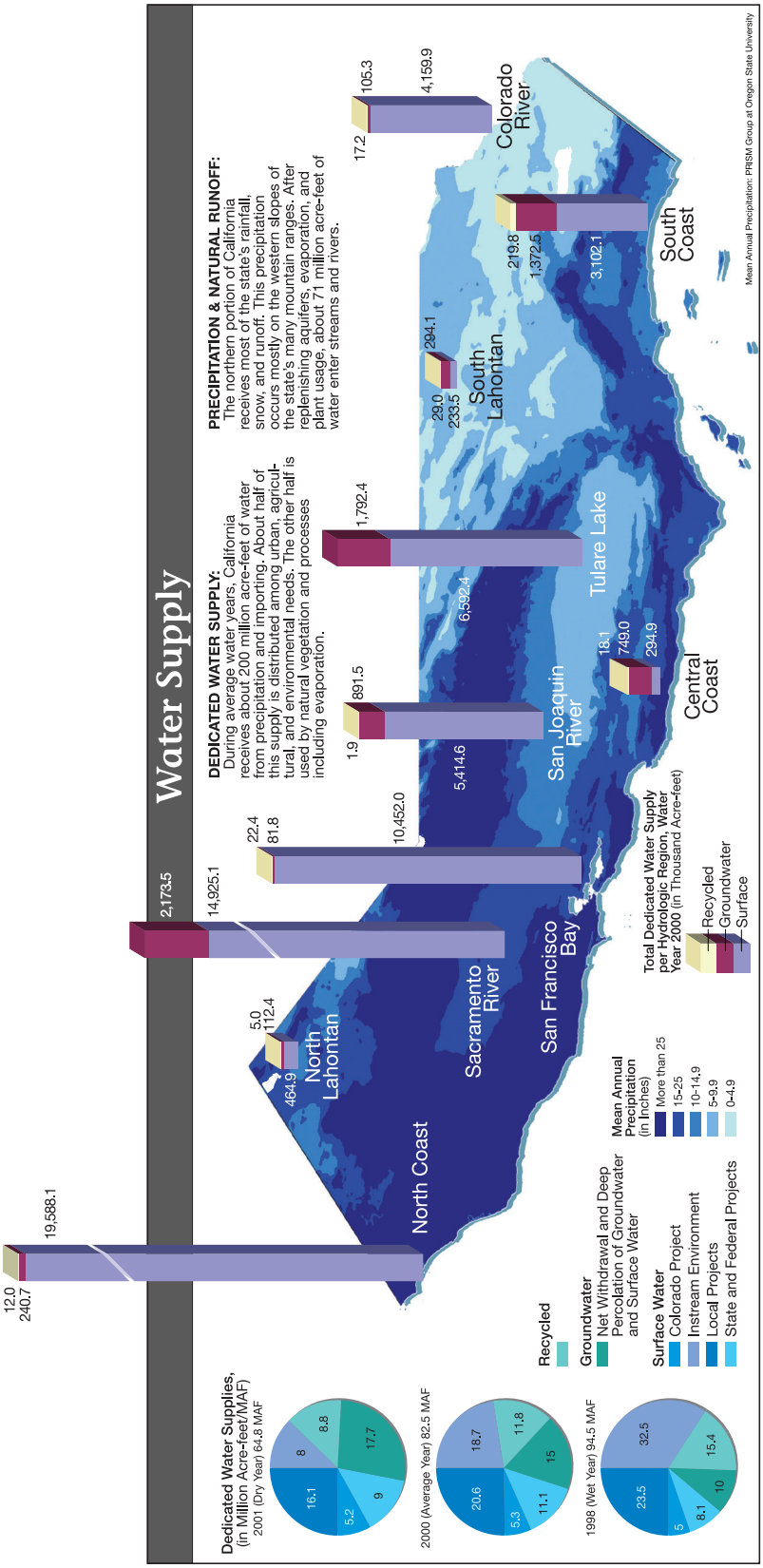
The Future

In an effort to expand on the work of CALFED, Governor Arnold Schwarzenegger signed Executive Order S-17-06 (September 2006), which called for an independent Delta Vision Blue Ribbon Task Force to develop a new strategy for managing the Delta as a healthy ecosystem that would continue to provide California with its critical water supply. Governor Schwarzenegger appointed seven task force members with experience in addressing and resolving complex natural resource management issues. The Task Force released its Final Delta Vision Strategic Plan in October 2008. The plan based on the goals of restoring the Delta ecosystem and creating a reliable water supply for California, described actions designed to restore the environment, promote water conservation, construct new aqueducts and reservoirs, respond to possible levee failures, and implement a new governance structure for the Delta.

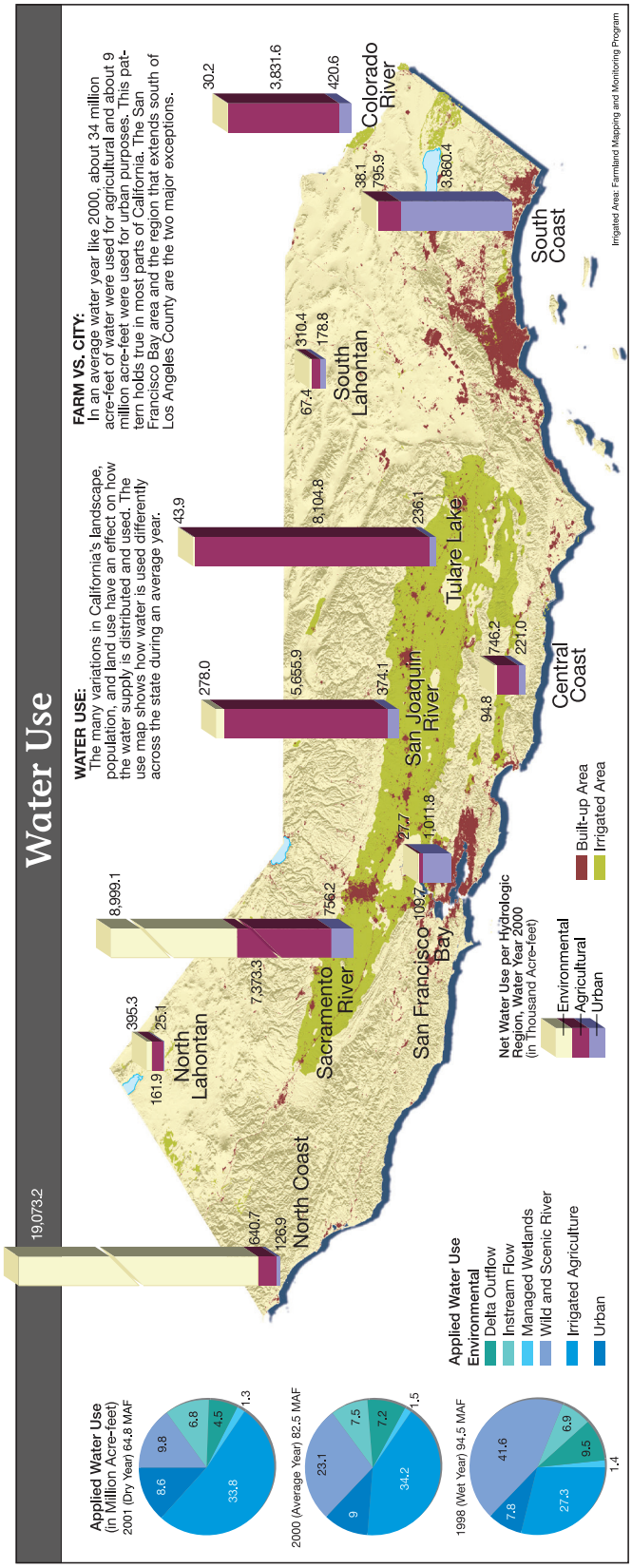
In December 2008, the Delta Vision Committee, made up of five appointees in the Governor's cabinet, evaluated the Strategic Plan and sent an Implementation Report containing their recommendations to the Governor and the Legislature. By February 2009, a number of bills relating to the funding, governance, and implementation of the Delta Vision had been introduced in both houses of the California Legislature.

San Francisco Bay

California's Water Supply



California's Water Use



The Central Valley Project

After the California Gold Rush in 1849, the population of California swelled. Many of the miners turned to cattle ranching when the gold ran out. Cattle ranching was successful in the Central Valley until the drought of 1863-1864 wiped out herds across the state. Ranchers turned to growing "dry" crops—plants that did not need to be watered. At the same time, the Bay-Delta region was being changed into farmland. Farmers built dikes to keep out salt water and canals to irrigate crops.

The success of the farmers depended on the weather. For the Bay-Delta farmers, too much rain meant flooding and loss of crops. Strong tides could push salt water farther into the estuarine system, contaminating the Delta water and rendering the Delta's freshwater supplies useless for human use. At the same time, the Central Valley ranchers could be wiped out by a drought in as little as two years.

In 1919, the first plan for the development of the Bay-Delta fresh water resources for the Central Valley and Bay-Delta was discussed in the California legislature. Engineers decided that the first step toward controlling the freshwater assets of the Bay-Delta area was to build a dam to stop the intrusion of salt water into the Bay-Delta region, and to funnel excess fresh water to the Central Valley. A dam to control the flow of the Sacramento River was considered key to solving the freshwater problems of the Bay-Delta and Central Valley agricultural concerns. The reservoir would also be a source of fresh water for urban areas that were growing rapidly.

The Central Valley Project (CVP) was started by the state, but money was scarce as the United States went into the Great Depression

of the 1930s. The federal government took over the Central Valley Project in 1933 and began construction of Shasta Dam in 1935, completing it in 1944. It is the second-largest dam in the United States, over 600 feet in height and over half a mile wide. During the summer and fall, the dam releases fresh water to help slow down saltwater intrusion in the Delta. In addition to controlling flooding, the hydroelectric facility at the Shasta Dam generates nearly 700,000 kilowatts of hydroelectric power. The dam is administered by the U.S. Department of the Interior, Bureau of Reclamation.

Today, the CVP consists of 20 dams and reservoirs, 11 hydroelectric power facilities, and over 500 miles (805 kilometers) of canals, tunnels, and pipes. This delivers about 7 million acre-feet of water for the needs of California. The electrical power serves 2 million people. This project plays a key role in California's economy, providing water for 6 of the 10 most important agricultural counties in the state.

Both the federal government and California's Department of Water Resources manage water in the Sacramento River and the Delta. Several agreements, including the Bay-Delta Plan Accord, dictate how the facilities are operated.

The State Water Project

California experienced a second "gold rush" after World War II ended in 1945. People flocked to the state, attracted by its climate and the lure of new jobs. Businesses and houses sprang up, especially in areas like San Francisco and Los Angeles. The growing population meant that new sources of water were needed. Wells tapped groundwater to irrigate the land to grow food for the growing population.

In 1945, the California Legislature studied water resources in the state. Their work resulted in the Feather River Project. The project included a dam, reservoir, and power plant near Oroville; a second flood control dam and power plant; a Delta cross channel, an electric power transmission system, an aqueduct to move water from the Delta to Bay Area counties; and another aqueduct to carry water from the Delta to the San Joaquin Valley and Southern California. In 1955 the Division of Water Resources (now Department of Water Resources) revised the project. They added the San Luis Reservoir and the South Bay Aqueduct to serve San Benito County. The North Bay Aqueduct was added to the project in 1957.

Approval of the project did not come easily. The project was the largest of its kind. Its costs and feasibility were questioned. Parties in the state's north and south opposed it. Northerners claimed the water was rightfully theirs and did not want their water flowing south, although the 1931 County of Origin Statute protected their future water needs. Southern California water agencies wanted assurance that supply

agreements would not be cancelled in the future. San Joaquin Valley farmers supported the project. So did the Teamsters, steelworkers, construction workers, and others who would gain from working on the project. The state decided to put the idea up for a vote.

The project became known as the Burns-Porter Act. It narrowly passed in the 1960 election. But construction on the Oroville site actually began before then. Emergency action was taken in 1957 after a record flood killed 64 people and destroyed $200 million in property in northern and central California. Building began on the South Bay and California aqueducts in 1959. The rest of the construction occurred in three major phases that lasted through 1974. Modifications and maintenance continue to this day. As of 2001, about $5.2 billion had been spent on these projects.

Today, the State Water Project is the nation's largest artificial water and power delivery system. It is maintained by the California Department of Water Resources (DWR) and provides water for 23 million Californians and 755,000 acres of irrigated farmland. It includes 32 storage facilities, reservoirs, and lakes; 17 pumping plants; 5 hydroelectric power plants; and about 660 miles (1,060 kilometers) of canals and pipelines. Water from this project is delivered to 29 urban and agricultural water suppliers, with about 70% going to urban users and 30% going to agriculture.

Adapted from: www.publicaffairs.water.ca.gov/swp/

Local Water Projects

Los Angeles Aqueduct

From the time that Los Angeles was first founded in 1769, the small settlement depended upon its own river for water. The 11 families that settled in the area dammed up the Los Angeles River and built canals to irrigate fields. But as the city grew, those in charge of supplying the growing population with water knew the small, meandering river could not meet future demands. In 1875, Frederick Eaton became the head of the Los Angeles Water Company, and hired William Mulholland as a ditch digger in 1878. When Eaton became mayor of Los Angeles in 1900, he created the Los Angeles Department of Water and Power. He appointed Mulholland as the superintendent. Together, they planned and organized the construction of the Los Angeles Aqueduct.

In 1904, Frederick Eaton traveled to Yosemite Valley on a family camping trip. He came back to Los Angeles through the Owens Valley. There he saw the Owens River. Eaton convinced Mulholland that the Owens River could provide Los Angeles with a reliable source of water. The land and water rights were secured by questionable means. (Eaton told Owens Valley residents he was buying land for a local irrigation project.) The Los Angeles Board of Water Commissioners needed to get funding for the project from Los Angeles residents, and legal rights from the federal government, to construct the aqueduct. A bond measure to pay for the construction passed in Los Angeles by a 10-to-1 margin. After much debate in Washington, President Theodore Roosevelt decided that Los Angeles should have the rights to the Owens River water. This decision was a key factor in the eventual growth of Los Angeles into the major urban center it is today. It was also a death knell for the farmers and ranchers of the Owens Valley who depended on that water. The struggle over these water rights is known as "The California Water Wars."

Construction of the Los Angeles Aqueduct began in 1905. It was made of 223 miles

(359 kilometers) of 12-foot- (3.7 meter) diameter pipe, tunnels, and open canals, and was considered an engineering marvel of that period. The aqueduct was completed in 1913, with Mulholland famously saying, as water from the aqueduct began thundering into the San Fernando Valley, "There it is. Take it." So much water was taken from the Owens River that Owens Lake dried up by 1924 and devastated the unique Mono Lake ecosystem. A second aqueduct was added, along the same path as the first, in 1970. In addition to taking water from the Owens River, groundwater pumping in the Owens Valley was utilized to increase the supply of water to Los Angeles. The maximum capacity of the two aqueducts is approximately 500,000 acre-feet per year. The Los Angeles Aqueduct system is managed by Los Angeles Department of Water and Power.

After nearly a century of economic and ecosystem devastation, water was allowed to flow back into the lower Owens River after a successful lawsuit by Attorney General Bill Lockyer, the Owens Valley Committee, and the Sierra Club. At the reopening of the river in 2006, Los Angeles Department of Water and Power board president David Nahai said to the witnesses, "Our message of friendship and gratitude to you is 'there it is...take it back.'"

Adapted from: http://wsoweb.ladwp.com/Aqueduct/historyoflaa/

Colorado River Aqueduct

The Colorado River flows across seven states. By 1922, six of these states signed the Colorado River Compact. The compact directed how the river water was to be divided. California was given 4.4 million acre-feet a year. Southern California's rights to Colorado River water were confirmed in the 1930s.

The Los Angeles Aqueduct had been marketed to the citizens of Los Angeles as a municipal water supply. Most of that water, however, was used for agriculture in the San Fernando Valley. More water was needed for the growing Los Angeles region. Mulholland thought about a new aqueduct to bring Colorado River drinking water to Los Angeles.

The Metropolitan Water District of Southern California (MWD) was formed in 1928 to get water from the Colorado River. Water was needed for 1.6 million people in 13 cities over a 600-square-mile area. The Colorado River Aqueduct was the largest public works project in Southern California during the Great Depression. It employed 30,000 people between 1933 and 1941. The aqueduct now serves many southern California communities.

The Colorado River Aqueduct is 242 miles (390 kilometers) long. It begins in Arizona at the Parker Dam. It crosses the southern Mojave Desert and enters the Coachella Valley north of the Salton Sea. It flows northwest along the Little San Bernardino Mountains. It crosses the San Jacinto Mountains and ends at Lake Mathews in Riverside County. From there the water is distributed to many communities in the MWD region. The project has two reservoirs, five pumping plants, 63 miles (101 km) of canals, 92 miles (148 km) of tunnels, and 84 miles (135 km) of buried pipes. Its capacity is 1.3 million acre-feet per year. The MWD currently serves 26 major cities and water districts over a 5,200-square-mile area, and provides water to more than 18 million people. Due to all of the water transfers, the Colorado no longer flows all the way to the Gulf of California in Mexico.

Adapted from: www.mwdh2o.com/mwdh2o/pages/yourwater/supply/colorado/colorado04.html

The Delta Smelt

The California Department of Fish and Game has been casting nets in the Delta for the last couple of weeks. It is not so much about what they catch, as what they do not catch. Since 1967, biologists have searched the murky waters of the Delta looking for what is left of the once-thriving fish populations. They take detailed notes on everything, from what they catch and where they catch it, to the temperature of the water. The number of fish the department catches is extremely small. "What we started noticing were downward trends, particularly at the start of 2000, 2001," said Dave Contreras of California Fish and Game. It is a phenomenon known as pelagic organism decline—a sudden and dramatic change in a population. In fact, several species continue to be at record lows.

"We've seen drastic abundance changes in delta smelt, end-of-the-year striped bass, longfin smelt, and threadfin shad," said Contreras. The longfin smelt numbers have been so low they could be put on the endangered species list. But it is the delta smelt that gets all the attention. It is only found in the Sacramento Delta. It is a tiny little fish with enormous importance. Scientists and environmentalists believe it is the best indicator of the Delta's overall health. It was listed as a threatened species in 1993 and is currently being considered as a candidate for the endangered species list.

In the seventies, according to catch data, scientists used to catch hundreds of smelt in a spot, in one station. No one really knows what is causing the decline, but scientists suspect everything from pollution, to pesticides, to invasive species, to the millions of gallons of water diverted to the Central Valley and Southern California. The delta smelt, like the salmon, lives in brackish or salt water during its adult life, but travels up the estuary to fresh water to spawn. It may be that the diversion of fresh water to the southern parts of the state has deprived the delta smelt of the natural conditions under which it thrived and bred. In 2008, a judge ordered a nearly 30% reduction in the amount of water being released to Southern California to protect the delta smelt. In a worst-case scenario, restrictions to protect both delta smelt and longfin smelt in 2009 could amount to nearly a 50% slash in water from the state's primary water delivery systems.

Delta smelt

Researchers are desperately trying to keep the Delta smelt from going extinct. "On-site,

we probably have about 50,000 fish," said Joan Lindberg, director of the UC Davis Fish Conservation and Culture Lab in Byron. Lindberg suspects her lab may have nearly as many fish in captivity as there are in the wild. Her goal is to preserve the genetic diversity of the species in case it does become extinct. They will soon begin rearing longfin smelt. The smelt raised there are primarily for research, but may someday provide a backup stock should the little fish disappear from the wild.

"There is a possibility if the population really looks like it's going to go extinct, that biologists will consider restocking some of these fish," said Lindberg. But putting the fish into the water now will not necessarily increase the numbers. Lindberg says there will have to be significant improvement in the health of the Delta in order for that to happen. According to the Department of Fish and Game, there is little sign of that happening. It will wrap up this season's count next month, but does not expect the numbers to change much. With each pull, there is less hope that the haul will show signs that the delta smelt population is recovering. "I think you might have to see 10 times as many fish coming in the hauls to say that it looks like it might be coming back," said Lindberg. And by Lindberg's assessment, that is a very long way off. "I think that humans have to work hard to repair some of the damages that they've caused in the past, and that will take years and years."

Text of "Delta Smelt Closer to Extinction" from Wednesday, November 26, 2008 | 6:59 PM Sacramento, CA (KGO). Written and produced by Ken Miguel. Used with permission of KGO-AM 810 Newstalk Radio, MediaSpan Network.

A Salty Situation

Irrigation of arid regions in California, such as the San Joaquin Valley over the past century, has helped fuel California, through agriculture, to become a world-leading economy. But irrigation of arid lands has some side effects. Increasing salinity of soils in the San Joaquin Valley is becoming a serious threat to agriculture in the region. Salinity is the measure of dissolved salts in water or soil. Ocean water contains about 35 parts of salt per thousand parts of water. Primary producers in the ocean are algae and certain kinds of bacteria. Seaweed and kelp are not plants—their structures are made up of single-celled algae, and they do not have the roots, stems, or capillary structures characteristic of land plants. Unlike seaweed and kelp, most land plants require fresh water to thrive. They draw fresh water from the soil into roots, and transport this water along with minerals and nutrients through stems and leaves. Production of fruits, stems, seeds, and roots declines with increasing salinity of soils and water.

Irrigation practices are blamed for the increase in salinity in the soils of the San Joaquin Valley and elsewhere. Even fresh water contains some salt, normally about 1/30th or less than that of ocean water. When crops in normally dry and hot areas are irrigated, the water is used by plants or evaporated from the soil, leaving behind the salt that was present in the water. Over time, the salt levels build up in the soil. In non-arid regions, rainfall and runoff remove salts from the soil, washing them out and delivering them to rivers and eventually the ocean. In dry, irrigated regions, water is too precious to allow for overwatering that would generate runoff and remove salts from the soil, so the salts accumulate. Prior to the construction of the Central Valley Project (CVP) and the State Water Project (SWP) in 1967, the primary source of irrigation water in the San Joaquin region was groundwater. From the start of large-scale agriculture in the 1900s to 1970, the salinity of the soils in this region slowly built up. When high-quality fresh water was supplied from the CVP and SWP, salinity levels initially declined. Yet because of a lack of drainage and a rising, salty water table, salinity of the soils is once again on the rise.

San Luis Drain

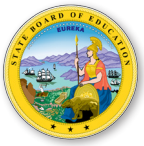
The United States Department of Agriculture estimates that more than 20% of the irrigated croplands in the United States suffer from salinization. The main factors that cause salinization of soils are a lack of fresh water, lack of drainage,

high water tables, use of fertilizers, and a naturally salt-rich environment. Land in the San Joaquin Valley is subject to all of these variables. The area was once the floor of an ancient seabed, resulting in a high salt concentration in local rocks and soils. In addition, a layer of clay confines the water table above it to relatively shallow depths. Salt that is leached out of surface soils is captured in the shallow groundwater.

To counteract the buildup of salinity in soils and groundwater in the San Joaquin Valley, the federal Bureau of Reclamation constructed the San Luis Drain and Kesterson Reservoir from 1968 to 1971. The system is 83 miles (134 kilometers) long and is made up of canals and evaporation ponds. For the next seven years after 1971, freshwater runoff from the agricultural fields provided habitat for a variety of wildlife including several species of fish and waterfowl. But the runoff from these fields contained pesticides and herbicides, and turned saline between 1978 and 1981.

Few species were able to tolerate the saline environment, and even fewer were able to tolerate the elevated levels of selenium. In 1983, there was a massive die-off of waterfowl. Salinity continued to increase, and the area was declared a toxic waste site in 1987. The San Luis Drain was closed, and the reservoir was drained and capped with soil to prevent further loss of migratory waterfowl. The salinization and poisoning of the reservoir was so sudden and severe that it is known as “the Kesterson Effect.” Two other regions at risk of toxic salinization in California are the Tulare Basin in the San Joaquin Valley and the Salton Sea in the Imperial Valley.

Scientists are considering the long-term sustainability of irrigated agriculture in the San Joaquin Valley and other regions. Studies are underway to determine if salt-tolerant or drought-tolerant crops, can allow continued use of these regions for agriculture. The efficiency and methods of irrigation are also being studied.



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